Low mass dilepton production at RHIC energies

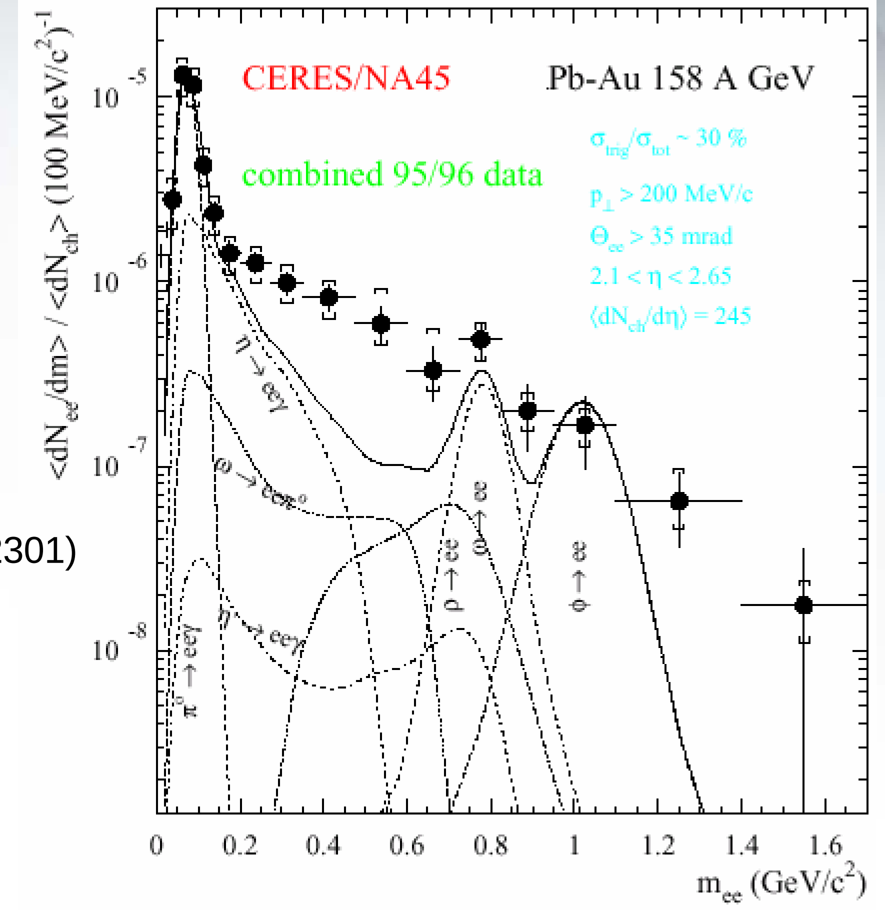
K. Ozawa for the PHENIX collaboration

Missing information at RHIC

- Contents of my talk

- Chiral symmetry restoration
  - Low mass vector mesons
- Thermal radiation
  - Dilepton continuum

CERES shows enhanced dilepton spectrum



At RHIC,

$\rho \to \pi^+\pi^-$ at STAR (Phys. Rev. Lett. 92, 092301)

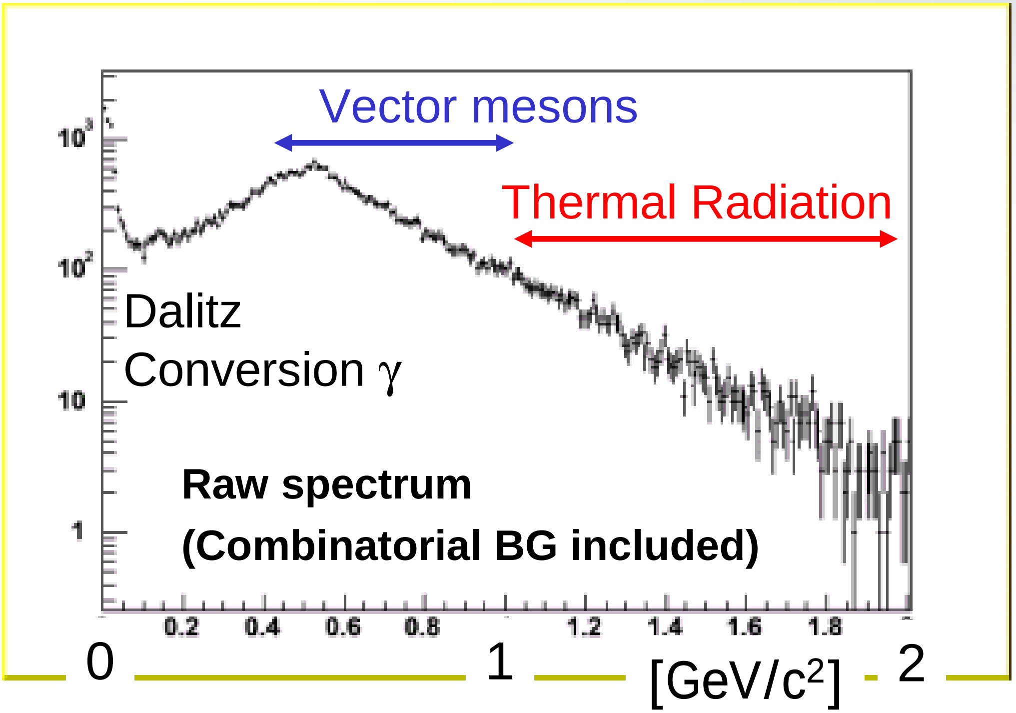
$\phi \to K^+K^-$ at PHENIX (nucl-ex/0410012)

STAR (nucl-ex/0406003)

Dilepton spectrum is needed.
PHENIX is designed to carry out such measurements.

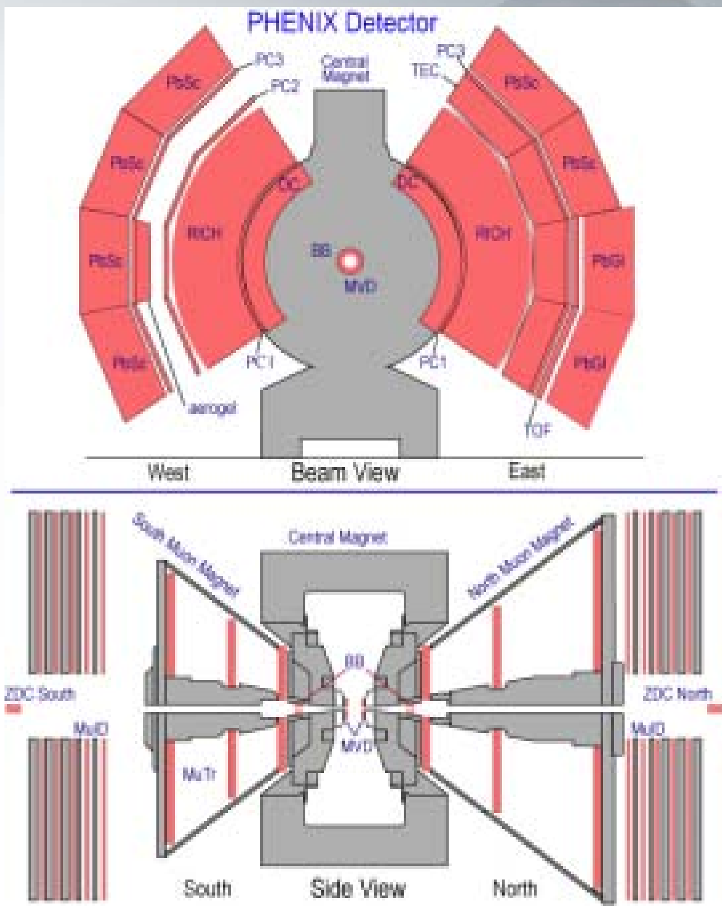
Current results are shown in this talk.

PHENIX experiment



Invariant mass spectrum of e^+e^- in PHENIX

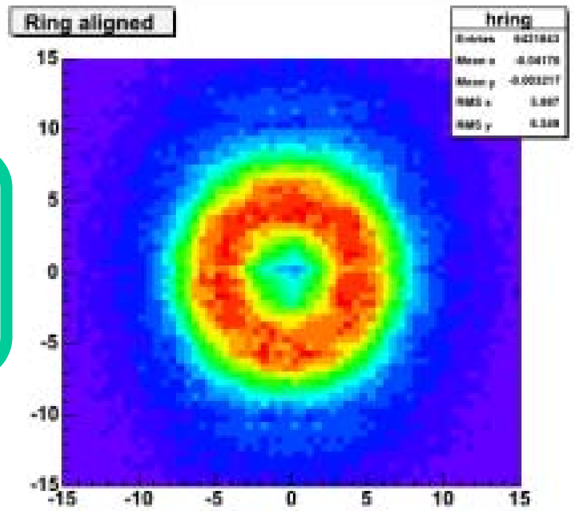
PHENIX can measure electrons in central region and muons in forward region.



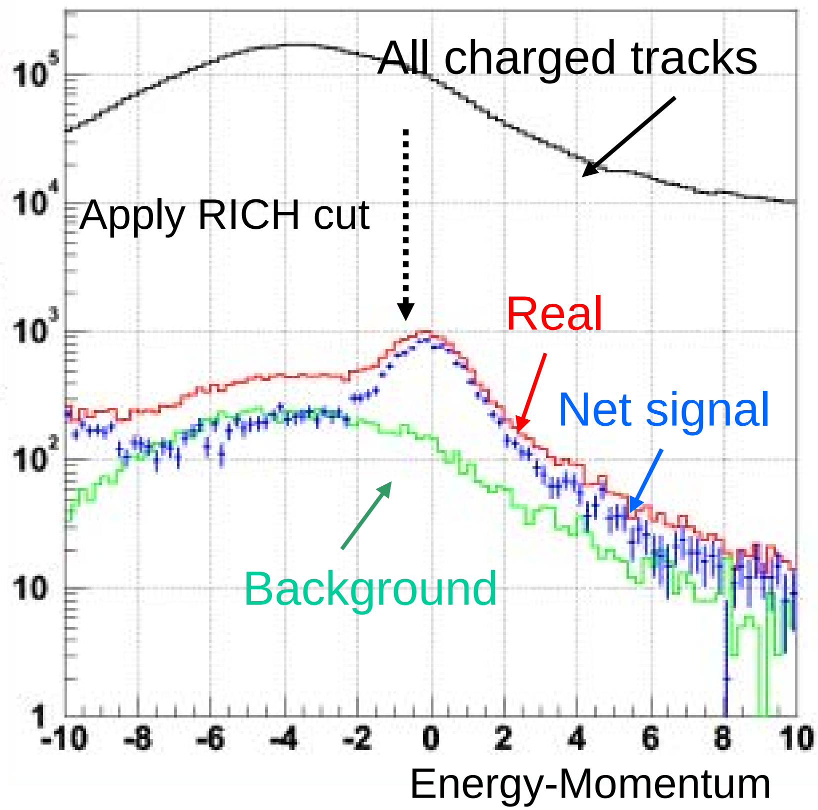
Electron measurement in PHENIX

- PHENIX achieved good electron measurements.
  - Single electron measurements show **charm production yield**.
- Electron identification is done by RICH and Energy-Momentum matching

Acceptance
|y| < 0.35
pT > 0.2 GeV/c



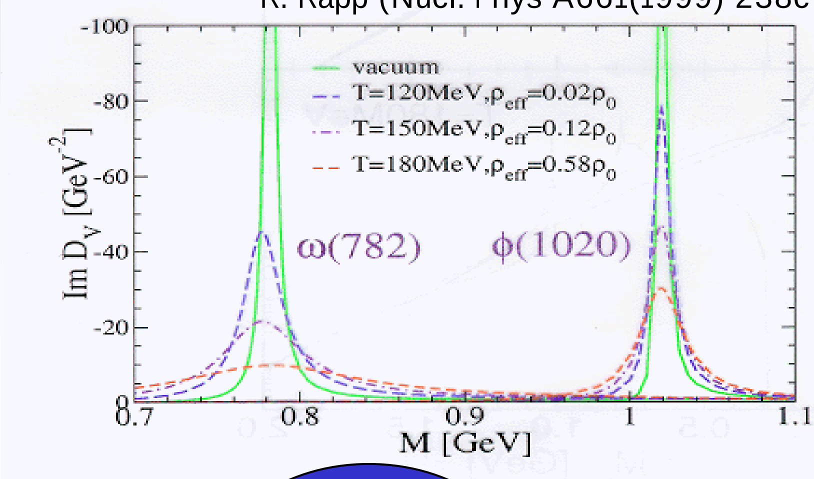
RICH ring shape

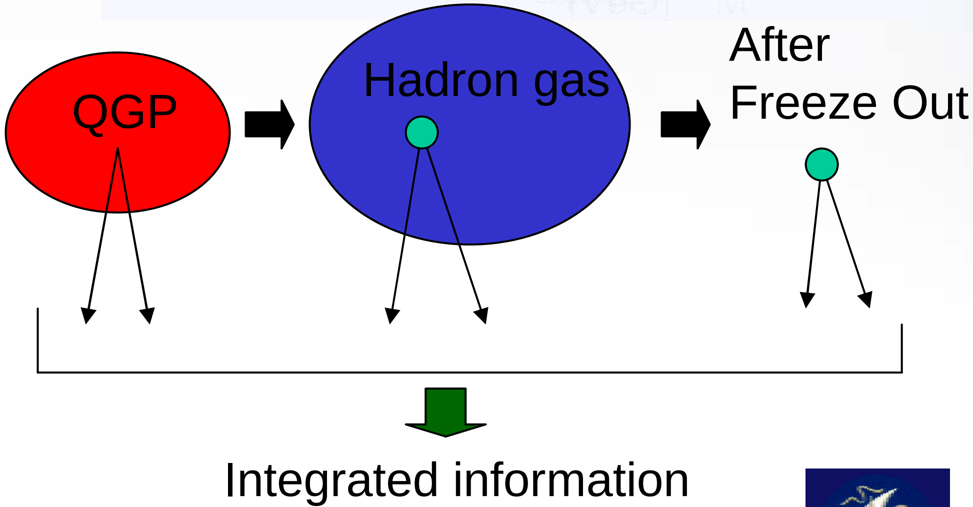


Dileptons in Hadronic matter

- Measurements of vector mesons as a signal of chiral symmetry restoration
  - Mass shift or modification is expected
- Lepton decays become good probes
  - Not interacting “strongly.”
  - However, we can see integrated information from all stages of collisions.
    - QGP, Mixed, Hadron gas
- Other baseline measurements are important.

R. Rapp (Nucl. Phys A661(1999) 238c





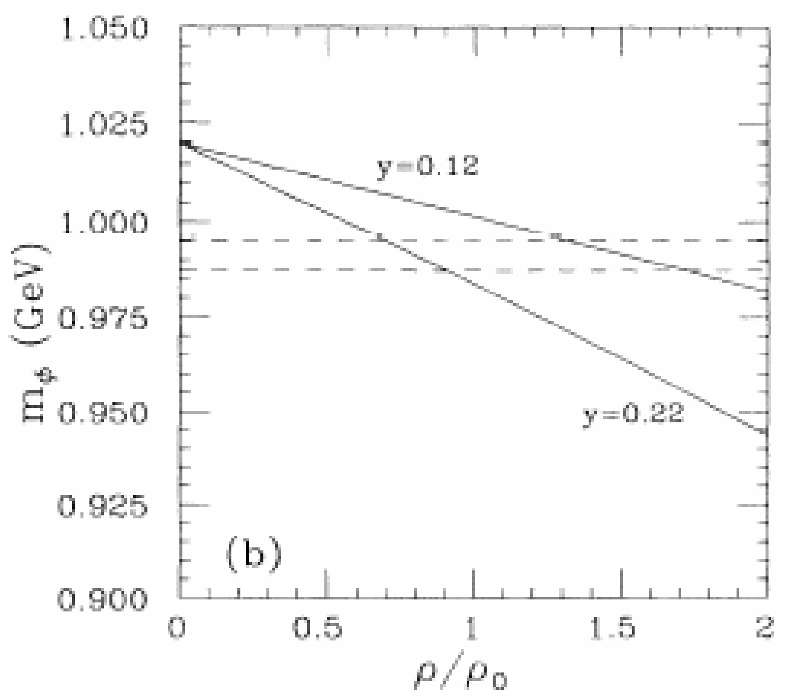
Observables in vector meson measurements

- Line shape
  - Direct measurements
- Yield
  - Q value of $\phi \rightarrow$ KK is small

$$\frac{BR(\phi \to ee)}{BR(\phi \to KK)}$$

  - Should be sensitive to mass changes in either ϕ or K

    Lissauer and Shuryak, Phys. Lett. **B253**, 15 (1991).
- pT slope
  - Difference between hadron decays and lepton decays
  - It could show the difference of collision stage.



T.Hatsuda and S.Lee

(Phys.Rev.C46-R34-38, 1992)

Experimental techniques

Line Shapes
Yield
pT slope

X

Compare with other baseline measurements

- d-A or p-p results
  - Extract expected signals without any "hot" nuclear matter effects.
- Hadron decays
  - $\phi \rightarrow K^+K^-$, $\rho \rightarrow \pi^+\pi^-$
  - Information from other collision stage.

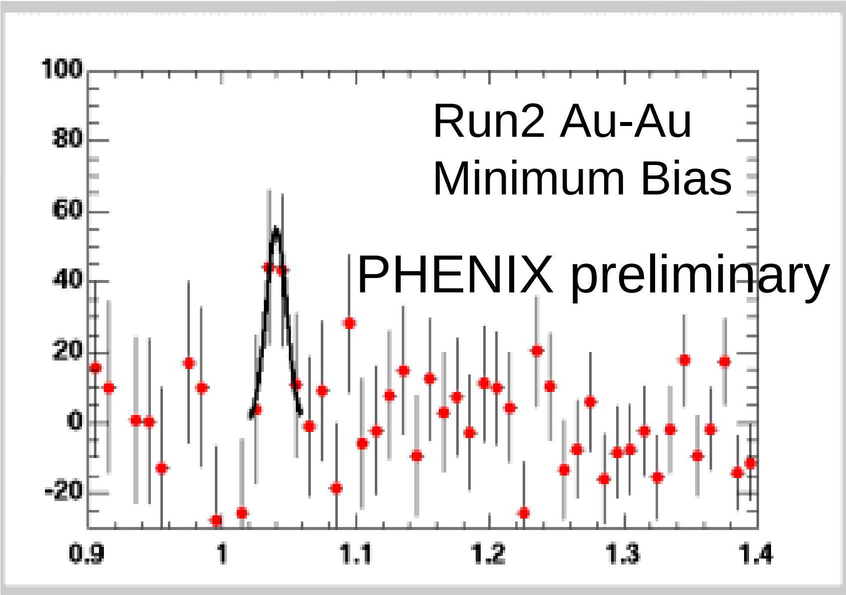
Centrality dependence

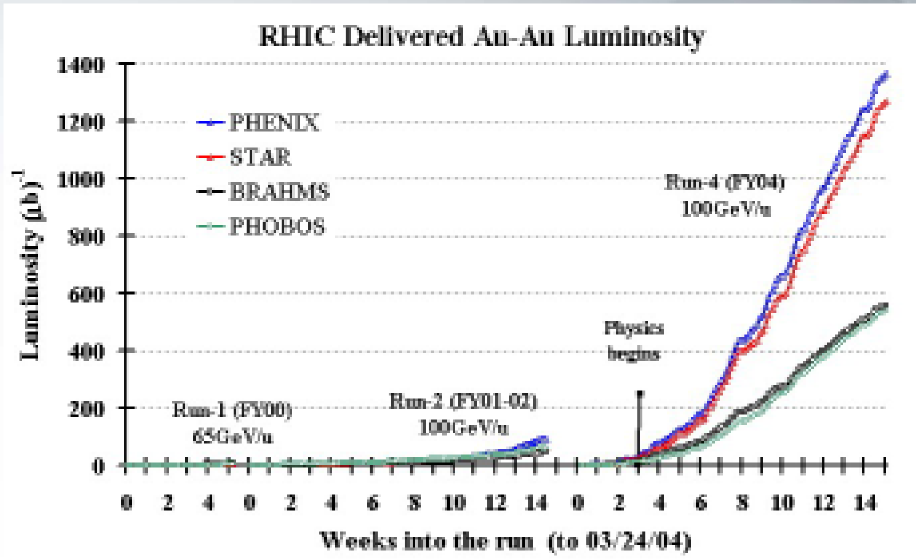
- Another baseline measurements in peripheral collisions.

$\beta\gamma$ dependence

- Slowly moving mesons have more effects.

Measurements of ϕ in AuAu





$$\text{Signal}=101\pm 47\,(\text{stat})^{+56}_{-20}\,(\text{sys})$$

Too large error to discuss line shape and yield

Need more statistics

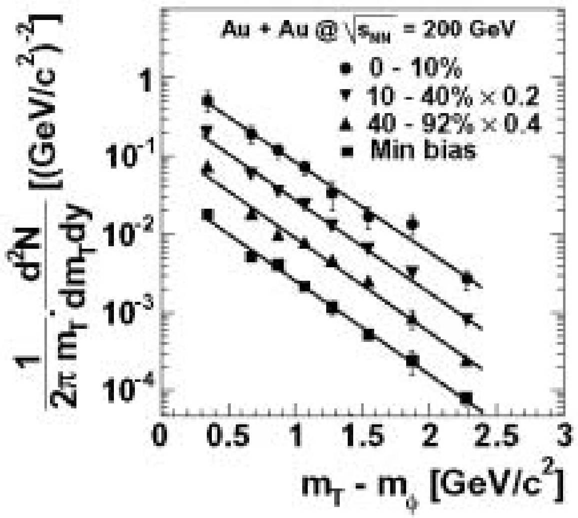
In Run4, 20 times larger luminosity is accumulated.

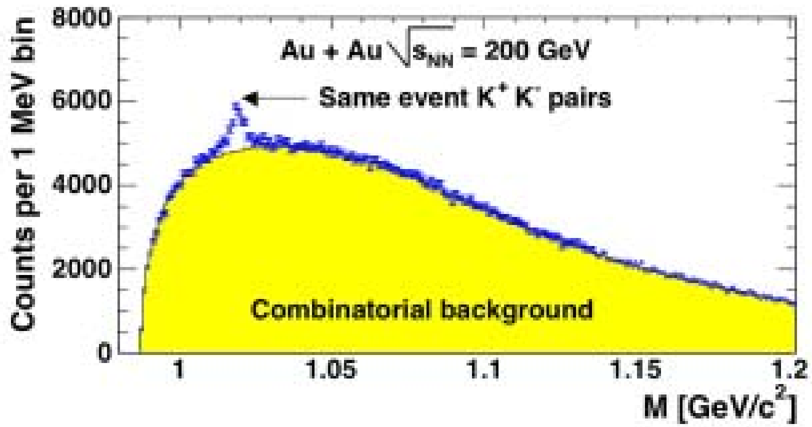
2 times larger pair acceptance

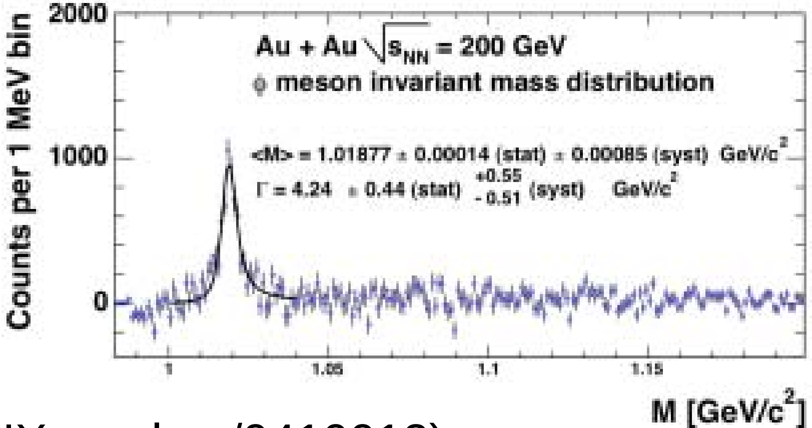
less background due to absence of multiplicity detector

Baseline $\phi \rightarrow KK$ in AuAu

- dN/dy (MB)
  1.16 +- 0.17 +- 0.19
- T (MB) (MeV)
  380 +- 18 +- 22





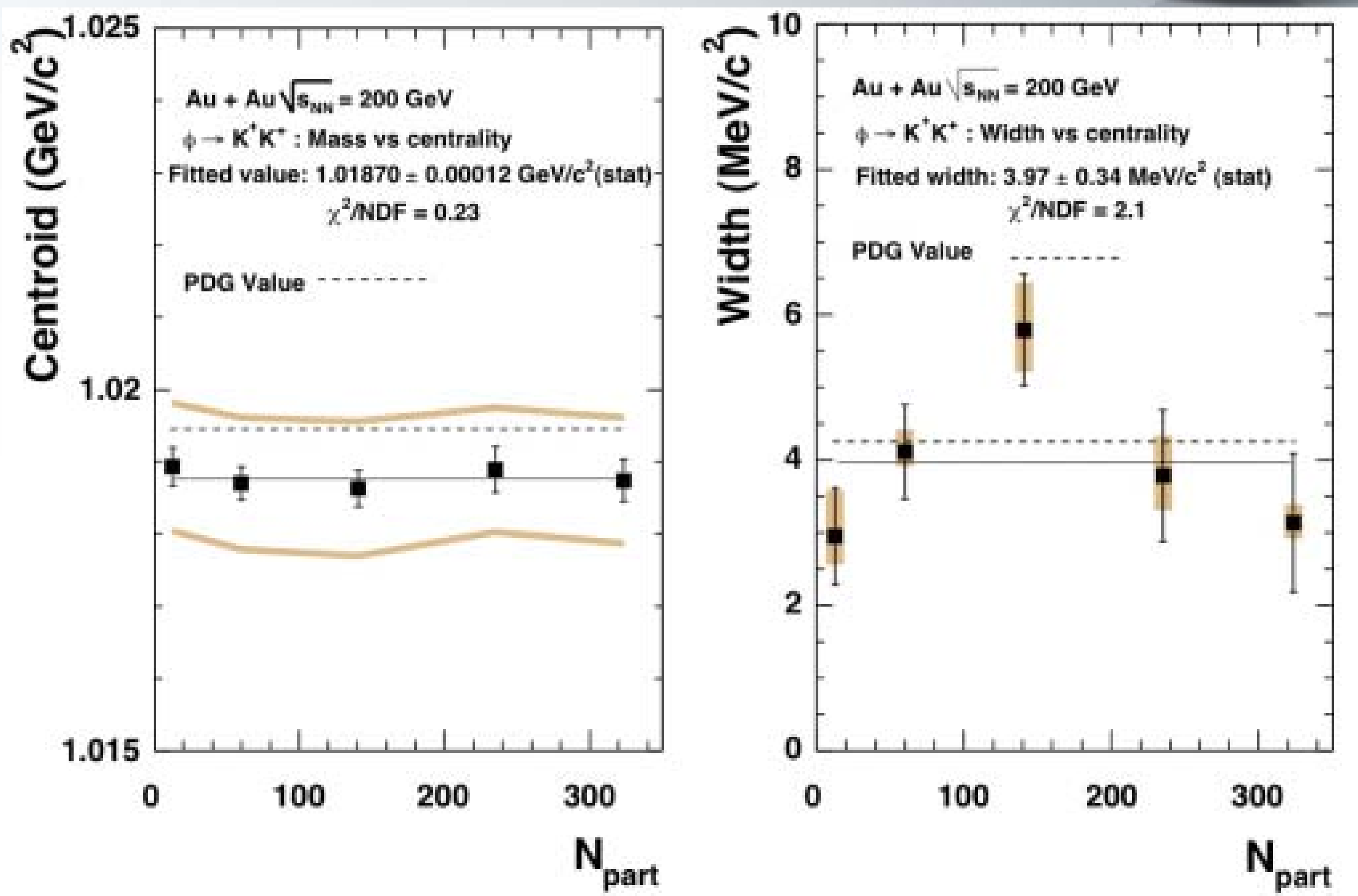


Ready for comparison with ee mode

(PHENIX, nucl-ex/0410012)

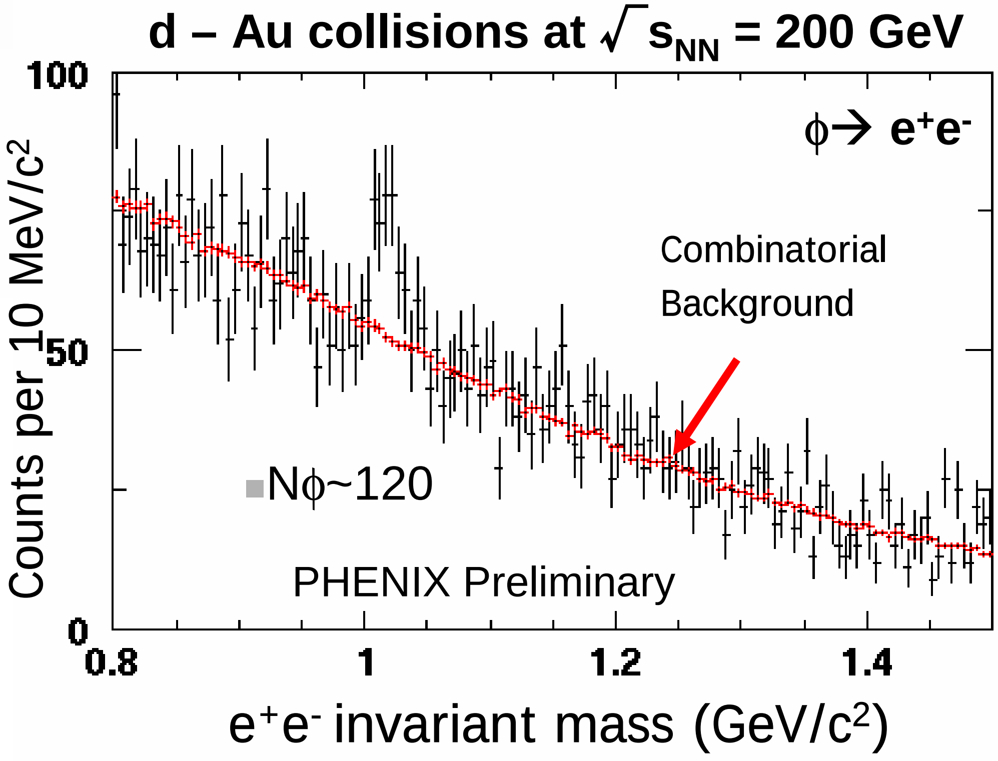
Line shape in $\phi \rightarrow KK$

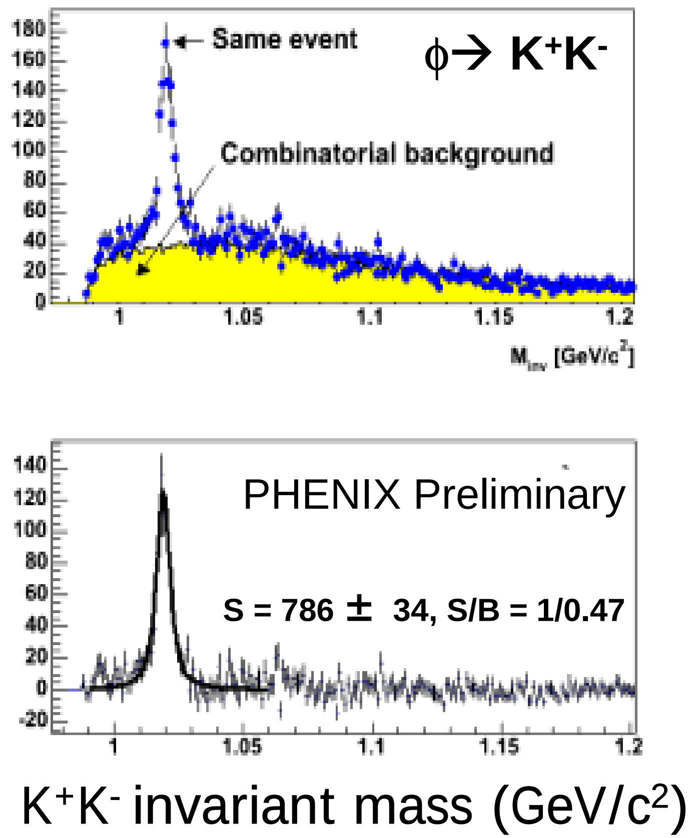
- Consistent with PDG values within the statistical and systematic errors.
- No significant change between centrality bins.
- Measured ϕ mesons are produced in the last stage of collision and/or in the surface of the matter.



(PHENIX, nucl-ex/0410012)

Another baseline - dAu





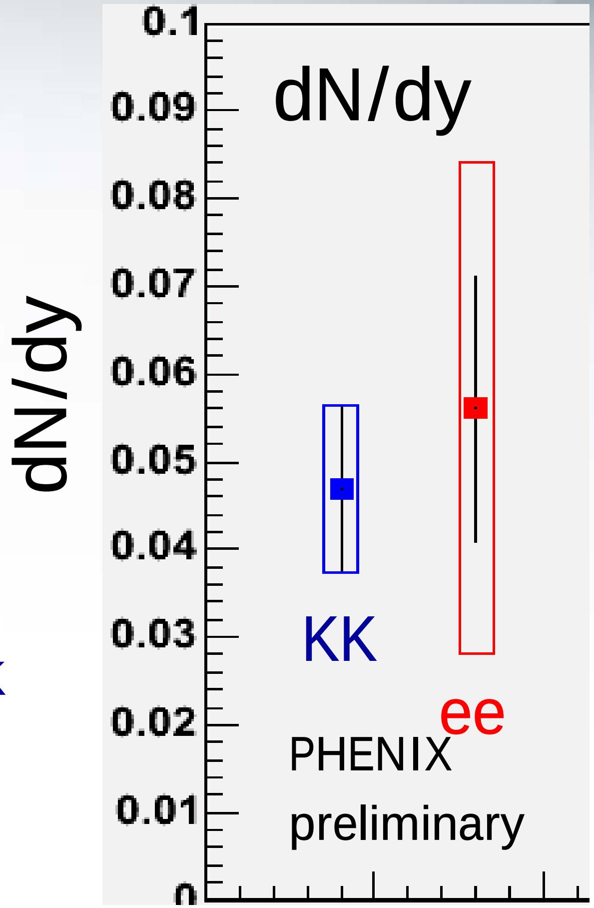
To settle cold nuclear matter effect, Both $\phi \rightarrow$ **e^+e^-** and $\phi \rightarrow$ **K^+K^-** are measured in d-Au collisions and results are compared.

dN/dy in dAu

- dN/dy is compared between ee and KK.

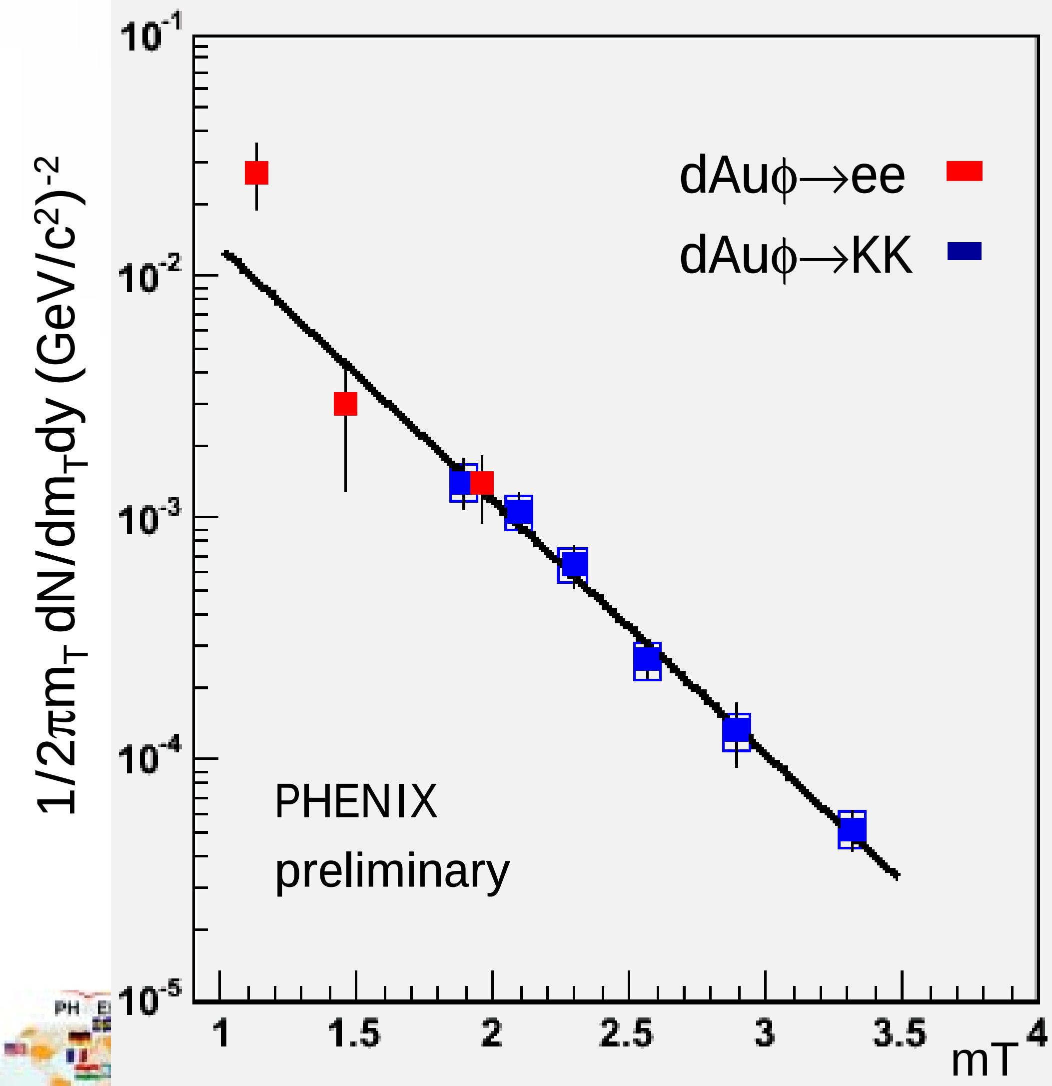
KK channel
dN/dy = 0.0468 +/- 0.0092(stat)
(+0.0095,-0.0092) (syst.)

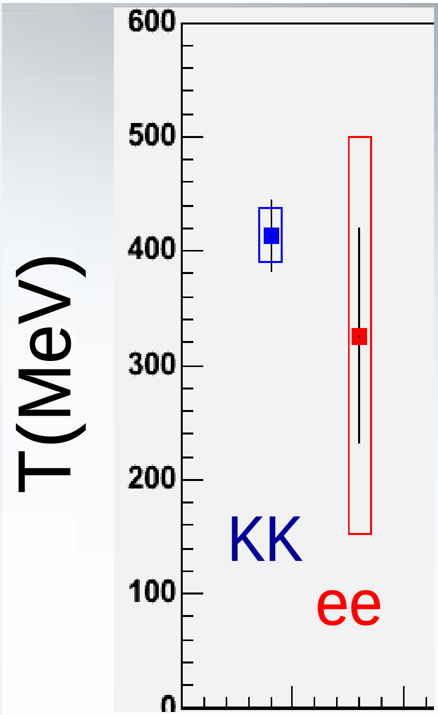
ee channel
dN/dy=.056±.015(stat) ±50%(syst)



No significant difference between ee and KK within statistical and systematic errors.

No difference in mT slope (dAu)





PHENIX
preliminary

KK channel
T (MeV) = 414 +/- 31 (stat)
+/- 23 (syst)

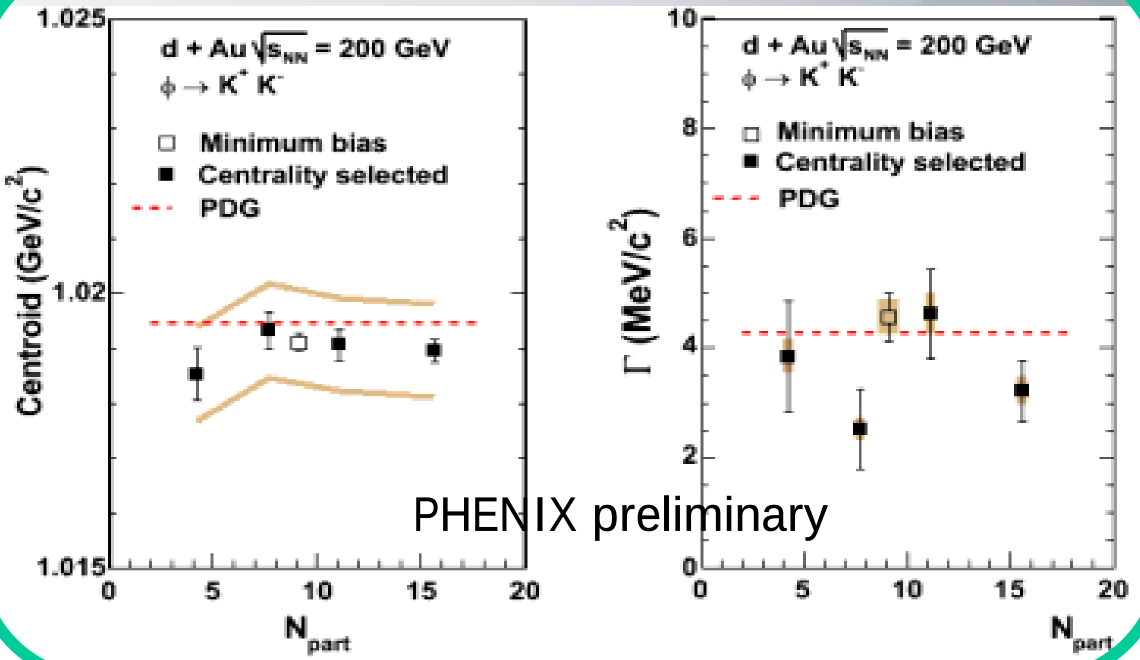
ee channel
T (MeV) = 326 +/- 94(stat)
+/- 53%(syst)

Line shape in dAu

$\phi \rightarrow ee$

- Spectrum is fitted with relativistic B-W and Gaussian
  - Width of B-W is fixed (Γ=4.46 MeV)
- Results
  - M=1.0177 $\pm$ 0.0023 GeV
  - σ_{exp}=8.1 $\pm$ 2.1 MeV
    - **Consistent with expected resolution**
  - χ^2/DOF=13.6/13

$\phi \rightarrow KK$



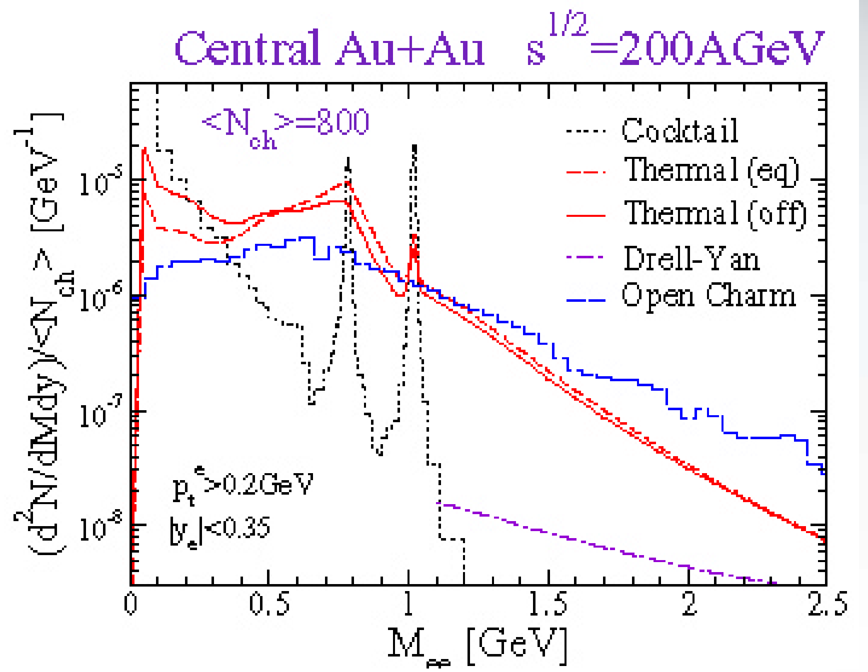
If the resolution of ee and KK is taken into account, they are consistent with PDG value.

No significant difference between ee and KK in dN/dy, mT slope, and line shape.

Thermal radiation

- Thermal radiation by the system via quark anti-quark annihilation carry direct information from the matter.
  - Matter is formed
  - Deconfinement
  - Thermalize
- Experimentally, combinatorial background is very large and must be subtracted properly.
- Large physics background comes from charm.
  - Charm production is measured with ~15% accuracy by single electron measurements.

A prediction

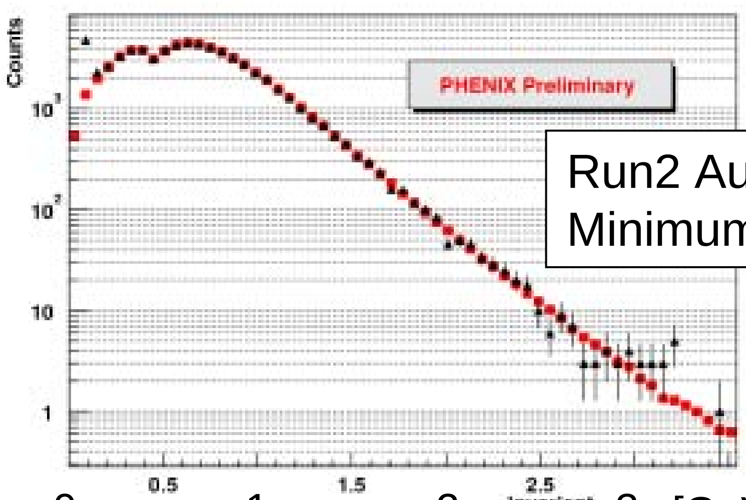


R. Rapp, nucl-ex 0204003

Thermal Radiation - electron

Invariant Mass of electron pair (GeV/c^2)

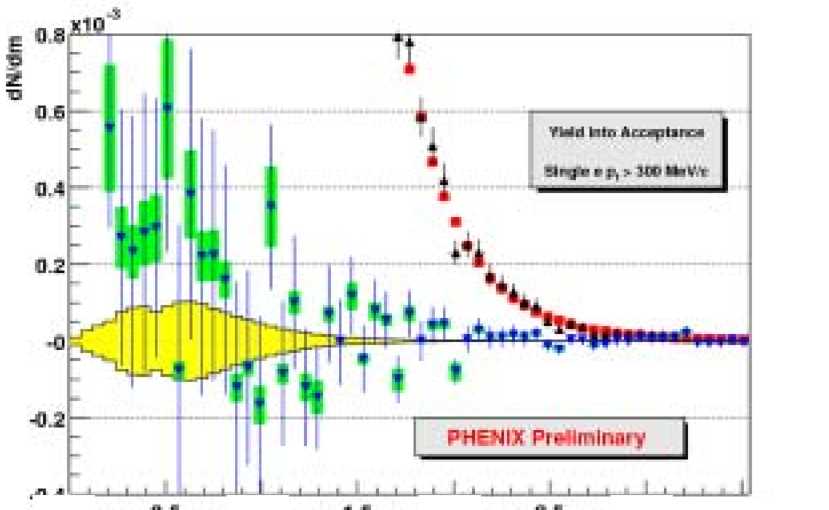
Real and **Mixed** e^+e^- Distribution



Run2 AuAu
Minimum Bias

0 1 2 3 [GeV/c^2]

Real - **Mixed** with systematic errors

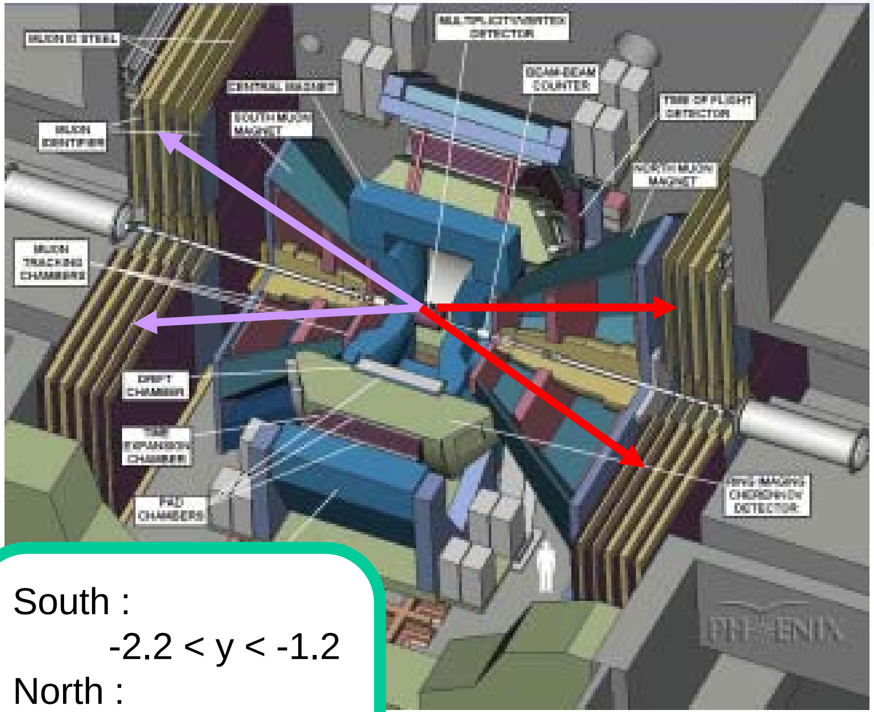


0 1 2 3 [GeV/c^2]

- Combinatorial background is determined with ~1% accuracy in Run3 and Run2 using a mixed event method.
- Analysis of Run4 data is underway.

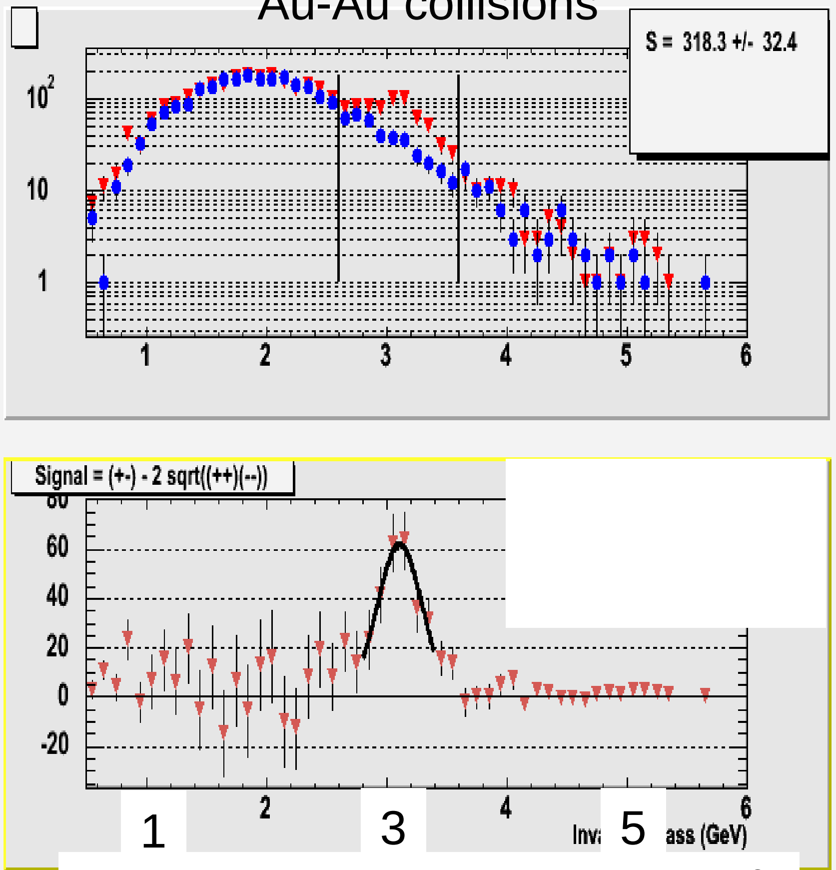
Muon pairs in intermediate region

- PHENIX can measure muon pairs in forward rapidity region.



South :
-2.2 < y < -1.2
North :
1.2 < y < 2.4
P > 2 GeV/c
$0 < \phi < 2\pi$

Au-Au collisions

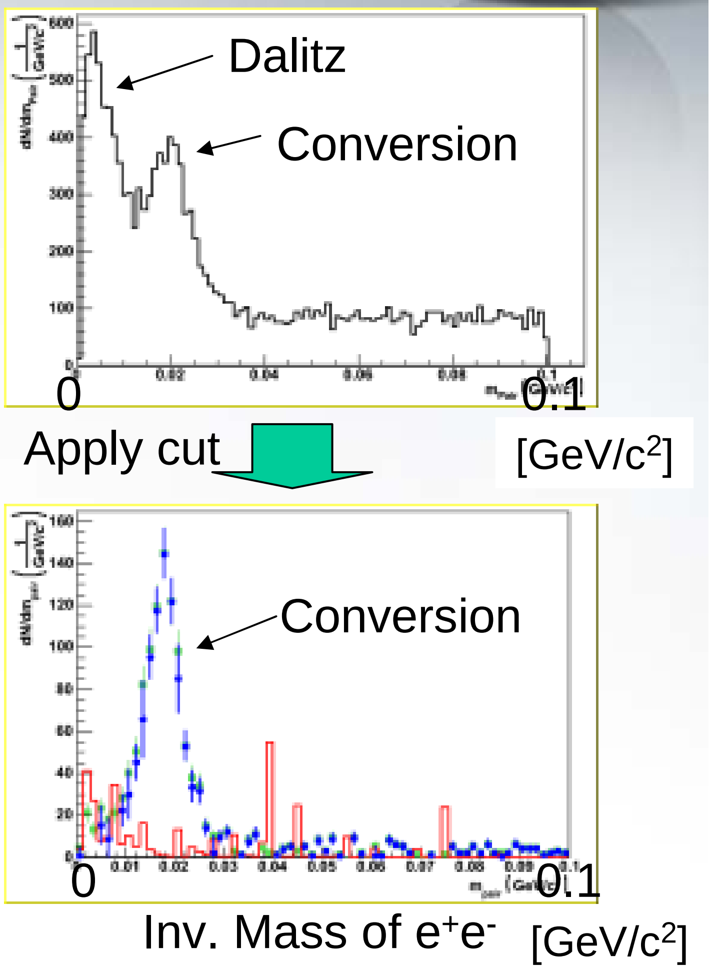


Invariant Mass of Muon pair (GeV/c^2)

Clear J/ψ peak is already obtained.

Another ability
Photon measurement - conversion

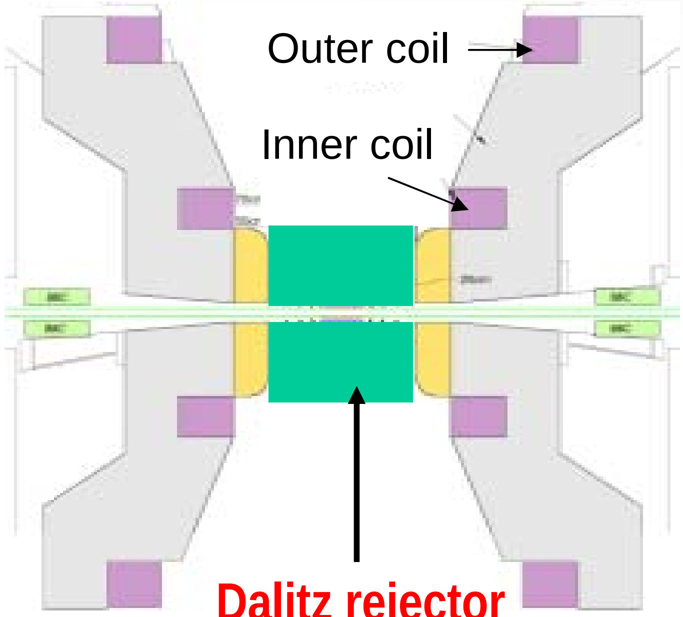
- Measurements using EM Calorimeter are already done and reported by K. Reygers in this conference.
- Amount of photons also can be measured by conversion pairs.
  - Pairs from Dalitz decays are background.
    - Conversion pairs can be selected by opening angle cuts
    - Projection of opening angle to x-y plane is different between Dalitz pairs and conversion pairs.

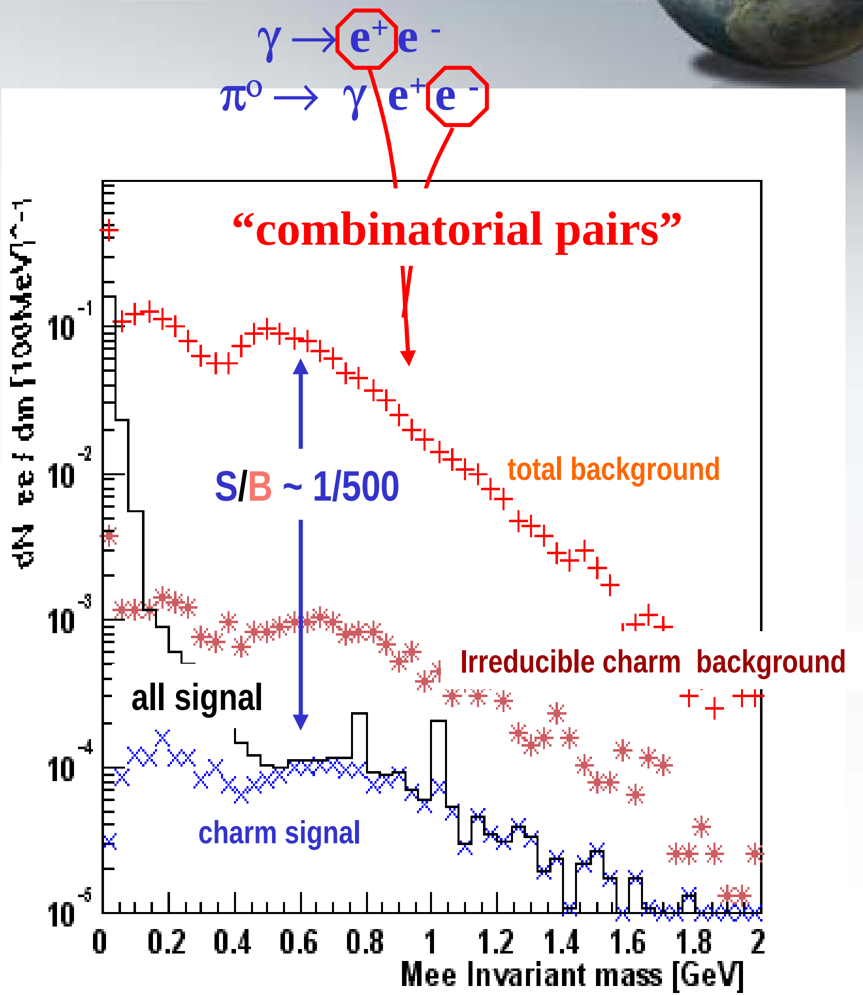


T. Dahms(PHENIX) in DNP

Near Future Upgrade

- For detailed study of dileptons in low mass region, suppression of background is essential
  - Daltz rejector is needed





AuAu Most Central collision

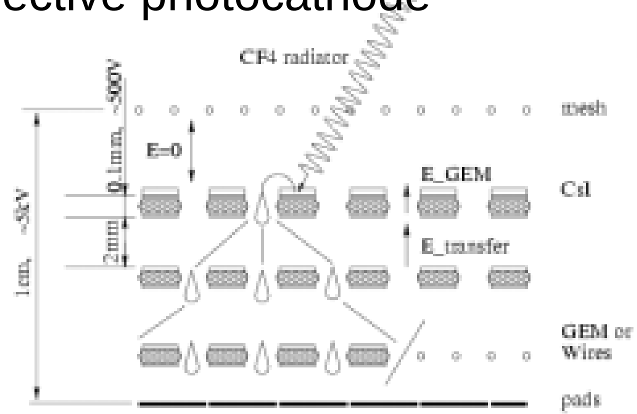
Hadron Blind Detector (HBD)

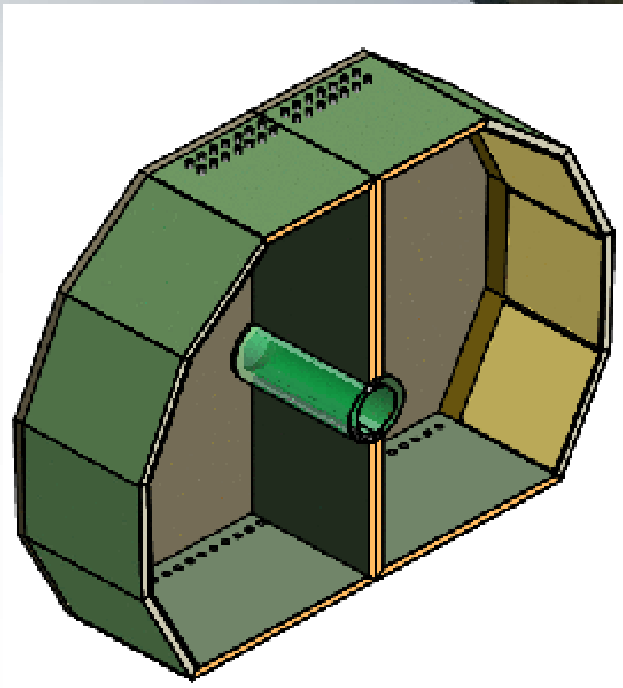
Dalitz rejection via opening angle

- Field-free region to maintain opening angle
- HBD for electron ID

HBD concept:

- windowless Cherenkov detector
- CF4 as radiator (50cm) and detector gas
- Triple GEM with pad readout
- CsI reflective photocathode





R&D at Weizmann institute

- Prototype construction is underway

It will be installed in time of Run6

Summary and Outlook

- Information of chiral symmetry restoration and thermal radiation at RHIC energy is not yet available.
- Baseline measurements, such as $\phi \rightarrow K^+K^-$ and measurements in dAu collisions, are done
- First results on low-mass dileptons from Run-4 Au+Au (2004) and Run-5 Cu+Cu (2005) are expected in the near future.
- For Run6, the Hadron Blind Detector will be installed to the PHENIX spectrometer, which will dramatically reduce combinatorial background.

PHENIX

Brazil University of São Paulo, São Paulo

China Academia Sinica, Taipei, Taiwan
China Institute of Atomic Energy, Beijing
Peking University, Beijing

France LPC, University de Clermont-Ferrand, Clermont-Ferrand
Dapnia, CEA Saclay, Gif-sur-Yvette
IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
SUBATECH, Ecòle des Mines at Nantes, Nantes

Germany University of Münster, Münster

Hungary Central Research Institute for Physics (KFKI), Budapest
Debrecen University, Debrecen
Eötvös Loránd University (ELTE), Budapest

India Banaras Hindu University, Banaras
Bhabha Atomic Research Centre, Bombay

Israel Weizmann Institute, Rehovot

Japan Center for Nuclear Study, University of Tokyo, Tokyo
Hiroshima University, Higashi-Hiroshima
KEK, Institute for High Energy Physics, Tsukuba
Kyoto University, Kyoto
Nagasaki Institute of Applied Science, Nagasaki
RIKEN, Institute for Physical and Chemical Research, Wako
RIKEN-BNL Research Center, Upton, NY
Rikkyo University, Tokyo, Japan
Tokyo Institute of Technology, Tokyo
University of Tsukuba, Tsukuba
Waseda University, Tokyo

S. Korea Cyclotron Application Laboratory, KAERI, Seoul
Kangnung National University, Kangnung
Korea University, Seoul
Myong Ji University, Yongin City
System Electronics Laboratory, Seoul Nat. University, Seoul
Yonsei University, Seoul

Russia Institute of High Energy Physics, Protovino
Joint Institute for Nuclear Research, Dubna
Kurchatov Institute, Moscow
PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
St. Petersburg State Technical University, St. Petersburg

Sweden Lund University, Lund

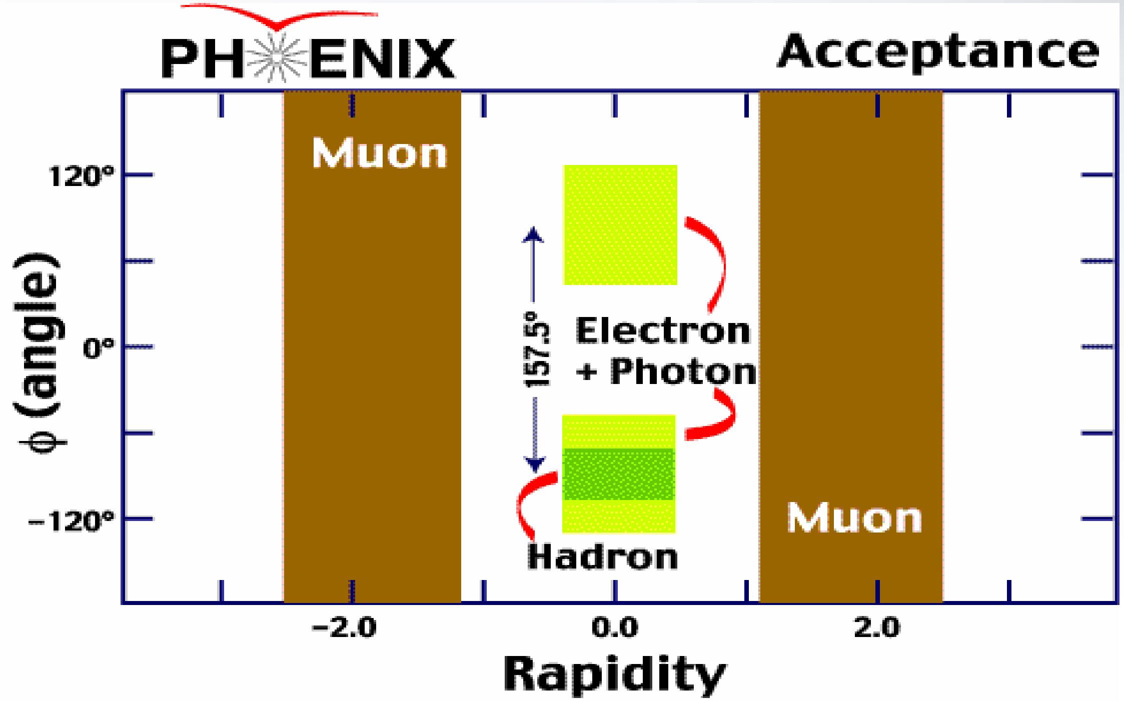
*12 Countries; 58 Institutions; 480 Participants**

USA Abilene Christian University, Abilene, TX
Brookhaven National Laboratory, Upton, NY
University of California - Riverside, Riverside, CA
University of Colorado, Boulder, CO
Columbia University, Nevis Laboratories, Irvington, NY
Florida State University, Tallahassee, FL
Florida Technical University, Melbourne, FL
Georgia State University, Atlanta, GA
University of Illinois Urbana Champaign, Urbana-Champaign, IL
Iowa State University and Ames Laboratory, Ames, IA
Los Alamos National Laboratory, Los Alamos, NM
Lawrence Livermore National Laboratory, Livermore, CA
University of New Mexico, Albuquerque, NM
New Mexico State University, Las Cruces, NM
Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
Oak Ridge National Laboratory, Oak Ridge, TN
University of Tennessee, Knoxville, TN
Vanderbilt University, Nashville, TN

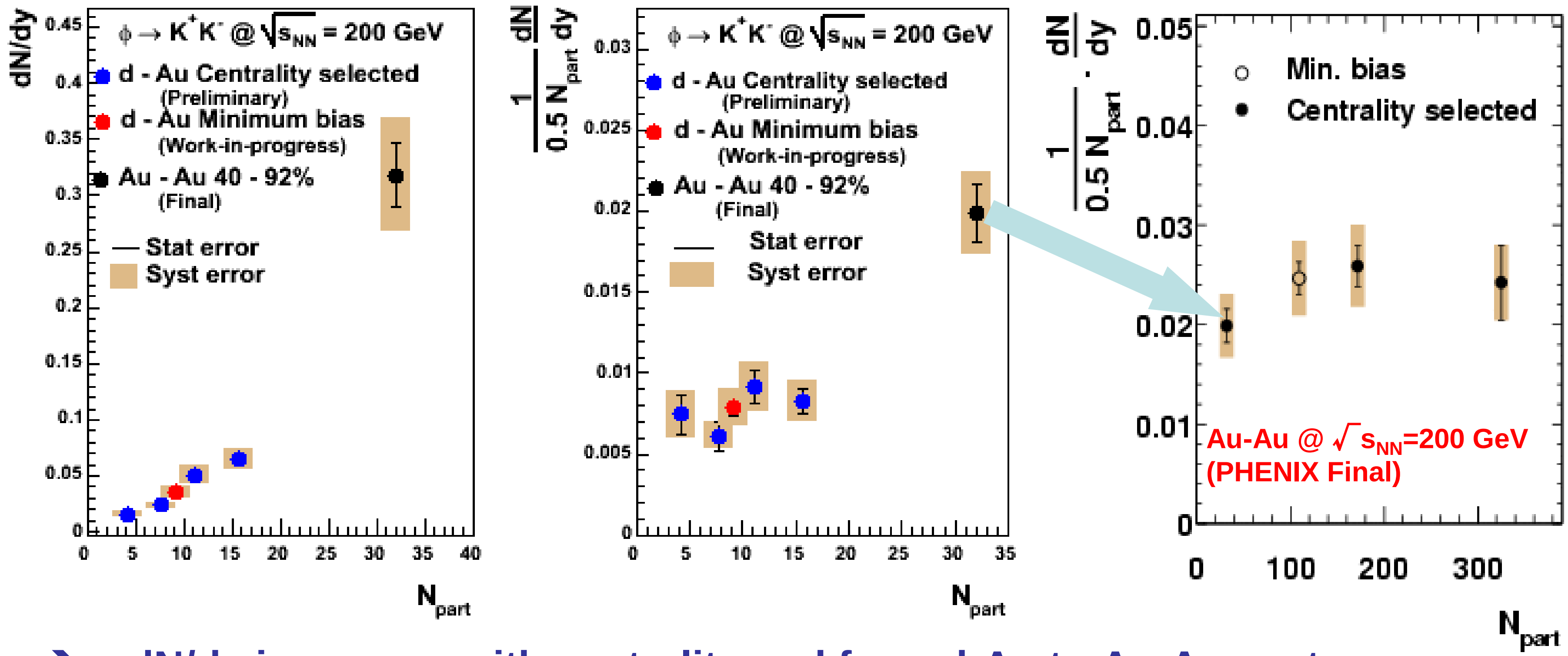
*as of January 2004

Backup

PHENIX Acceptance



Centrality dependence: Yield



➔ dN/dy increases with centrality and from d-Au to Au-Au system.

➔ dN/dy per participant pair is flat for d-Au system within errors, but increases from d-Au to Au – Au system.